IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re application of:	Dennice F. GAYME et al.	Group Art Unit: 3664
Serial No.:	10/628,085	Examiner: R. M. Mancho
Filed:	July 24, 2003	Confirmation No.: 3521

For: FAULT DETECTION SYSTEM AND METHOD USING AUGMENTED DATA AND FUZZY LOGIC

Docket No.:	H0005645-3008
Customer No. :	00128

CERTIFICATION OF EFS-WEB TRANSMISSION UNDER § 1.8

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By: /S. Jared Pitts /.

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APPEAL BRIEF PURSUANT TO 37 C.F.R. § 41.37

This is an Appeal Brief under 37 C.F.R. § 41.37 appealing the rejections set forth in the Final Office Action dated May 12, 2009. Each of the topics required by 37 C.F.R. § 41.37 is presented in this Brief and is labeled appropriately.

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I. REAL PARTY IN INTEREST

Honeywell International, Inc. ("Honeywell") is the real party in interest of the present application. An assignment of all rights in the present application to Honeywell was executed by the inventors and recorded by the U.S. Patent and Trademark Office at **Reel 014802, Frame 0677**.

II. RELATED APPEALS AND INTERFERENCES

There are no appeals or interferences related to the present application of which Appellant is aware.

III. STATUS OF CLAIMS

Claims 1, 5-7, 9-11, 31, 33-35 and 37-45 are pending in this application and are involved in this appeal, with Claims 1, 31 and 39 being the independent claims. Claims 2, 21, 25, 26, 28-30 have been withdrawn pursuant to a restriction requirement. Claims 3, 4, 8, 12-20, 22-24, 27, 32 and 38 have been cancelled.

IV. STATUS OF AMENDMENTS

All amendments have been entered. There were no after final amendments.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The embodiment encompassed by independent claim 1 relates to a fault detection system for detecting faults in a turbine engine. The fault detection system includes a sensor data processor and a fuzzy logic inference system. (See figure 1; page 2, lines 12-20.) The sensor data processor is configured to receive sensor data from the turbine engine and generate residuals from the sensor data and determine a rate of change of the residuals, where the he residuals from the sensor data and the rate of change of the residuals provide an augmented data set. (See page 2, lines 21-28.) The fuzzy logic inference system is configured to receive the augmented data set, and includes a plurality of membership functions. (See figure 5; page 2, lines 21-28) Each of the plurality of membership functions is associated with at least one data type in the residuals and the rate of change of the residuals. (See figures 6-9; page 13, lines 20-31; page 14, lines 1-14.) The fuzzy logic system is configured to fuzzify the residuals from the sensor data and the rate of change of the residuals using the plurality of membership functions and analyze the residuals from the sensor data and the rate of change of the residuals to determine a likelihood that a fault has occurred in the turbine engine. (See page 14, lines 15-23; page 15, lines 1-29.)

The embodiment encompassed by independent claim 31 relates to an apparatus that includes a processor, a memory coupled to the processor, and a fault detection program residing in memory and being executed by the processor. (See figure 12). The fault detection program includes a sensor data processing program and a fuzzy logic inference program. The sensor data processing program configured to receive sensor data from a turbine engine and generate residuals from the sensor data, and determine a rate of change of the residuals to provide an augmented data set. (See page 2, lines 21-28.) The fuzzy logic inference program includes a plurality of membership functions (See figure 5; page 2, lines 21-28), wherein each of the plurality of membership functions is associated with at least one data type in the residuals from the sensor data and the rate of change of the residuals. (See figures 6-9; page 13, lines 20-31; page 14, lines 1-14.) The fuzzy logic inference program is configured to receive the augmented data set and fuzzify the residuals from the sensor data and the rate of change of the residuals using the plurality of membership functions and analyze the residuals from the sensor data and the rate of change of the residuals to determine a likelihood that a fault has occurred. (See page 14, lines 15-23; page 15, lines 1-29.)

The embodiment encompassed by independent claim 39 relates to a fault detection system for detecting faults in a turbine engine. The fault detection system includes a sensor data processor and a fuzzy logic inference system. (See figure 1; page 2, lines 12-20.) The sensor data processor is configured to receive sensor data from the turbine engine (See page 2, lines 21-28.), where the sensor data includes exhaust gas temperature data, engine speed data, and fuel flow data, generate exhaust gas temperature residuals by comparing the exhaust gas temperature data to expected values of exhaust gas temperature, generate engine speed residuals by comparing the engine speed data to expected values of engine speed, generate fuel flow residuals by comparing the fuel flow data to expected values of fuel flow. (See page 5, lines 28-32; page 6, lines 1-17; page 13, lines 12-19) determine a rate of change of the exhaust gas temperature residuals; determine a rate of change of the engine speed residuals; determine a rate of change of the fuel flow residuals (See page 7, lines 4-20). The fuzzy logic inference system includes a plurality of membership functions. (See figure 5; page 2, lines 21-28) The fuzzy logic inference system is configured to receive the exhaust gas temperature residuals, the engine speed residuals, the fuel flow residuals, the rate of change of the exhaust gas temperature residuals, the rate of change of the engine speed residuals, and the rate of change of the fuel flow residuals. (See page 13, lines 7-31) The fuzzy logic system is configured to fuzzify the exhaust gas temperature residuals, the engine speed residuals, the fuel flow residuals, the rate of change of the exhaust gas temperature residuals, the rate of change of the engine speed residuals, and the rate of change of the fuel flow residuals using the plurality of membership functions to determine a likelihood that a fault has occurred in the turbine engine (See page 14, lines 1-23; page 15, lines 1-29).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The grounds of rejection to be reviewed in this appeal are as follows:

1. Claims 1, 5-7, and 9-11 were rejected under 35 U.S.C. § 103 as allegedly being unpatentable over U.S. Patent Publication No. 2003/0139860 to McBrien et al (hereinafter McBrien) in view of Wikipedia Encyclopedia.

2. Claims 31, 33, 34, 36-38 were rejected under 35 U.S.C. § 103 as allegedly being unpatentable over McBrien in view of Martucci (U.S. Patent No. 6289274) and in further view of the Wikipedia document.

3. Claims 39-45 were rejected under 35 U.S.C. § 103 as allegedly being unpatentable over McBrien in view of Brown et al (U.S. Patent No.5377112).

VII. ARGUMENT

1. Claims 1, 5-7, and 9-11 are not unpatentable under 35 U.S.C. § 103 over U.S. Patent Publication No. 2003/0139860 to McBrien et al (hereinafter McBrien) in view of Wikipedia Encyclopedia.

A. Rejections under 35 USC §103

In the final office action, claims 1, 5-7, and 9-11 were rejected under 35 U.S.C. § 103 as allegedly being unpatentable over U.S. Patent Publication No. 2003/0139860 to McBrien et al (hereinafter McBrien) in view of Wikipedia Encyclopedia. The Examiner stated that McBrien discloses a fault detection system for detecting faults in a turbine engine, where the fault detection system includes a sensor data processor providing an augmented data set and a logic inference system, the logic inference system analyzing the augmented data set to determine the likelihood that a fault has occurred. In making these rejections, the Examiner cited elements 12, 14 and 16 as disclosing a sensor data processor, and element 30 of FIG. 3 as disclosing a fuzzy logic inference system. The Examiner cited the Wikipedia entry as teaching that power is a rate at which work is done with respect to time, and that the rate of change of work with respect to time is power.

B. Analysis

The Examiner bears the initial burden of establishing a *prima facie* case of obviousness. In re Fine, 837 F.2d 1071, 1074 (Fed. Cir. 1988). In particular, the Examiner has the burden of articulating a factual basis for combining the cited references. Indeed, as the Supreme Court recently reiterated, it is "important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does." KSR International Co. v. Teleflex Inc., 127 S. Ct. 1727, 1741 (2007). Furthermore, a claim cannot be found *prima facie* obvious unless all of the claim elements are either taught or suggested in the cited art or form part of the knowledge of one of ordinary skill in the art, or all of claim elements are obvious from the nature of the problem itself. In re Dembiczak, 175 F.3d 994, 999 (Fed.

Cir. 1999) (emphasis added); In re Wilson, 424 F.2d 1382, 1385 (C.C.P.A. 1970) ("All words in a claim must be considered in judging the patentability of that claim against the prior art.").

Appellants submit that when analyzed according to these standards, the claims are patentably distinct over the cited references.

First, with regard to the sensor data processor, in the final office action, the Examiner alleged that elements 12, 14 and 16 of McBrien constitute the recited sensor data processor, stating that these elements are configured to augment the sensor data by generating residuals and determining a rate of change of the residuals. Specifically, the Examiner cites to McBrien teaching generating residuals in that "raw sensor data are filtered or conditioned thus forming residuals." Next, the Examiner cites the McBrien as teaching a rate of change of the residuals in the form of a "horsepower which constitutes rate of change of work done". Furthermore, in response to Appellants' previous arguments, the Examiner now admits that "rate" is a form "ratio", but states that because sensor data is shown as mapped in FIG. 5 and that graphs show a slope, that a rate of change has been determined.

Appellants submit that this is a misreading of the McBrien reference, and that the McBrien reference fails to teach the recited sensor data processor.

First, with regard to the recited sensor data processor being configured to "generate residuals", appellants note the specification defines "residuals" as the difference between the sensor data and the expected values of the sensor data. See appellants' specification at page 5, lines 3-6. Appellants submit that the teachings of McBrien fail to meet this limitation as so defined. Appellants note that the Examiner seems to rely on teachings of filtering and conditioning in McBrien to teach this limitation. Appellants submit that, given the definition of residuals found in the specification, neither the cited "filtered" or "conditioned" sensor data by itself meets the limitation of a generated "residual".

Second, with regard to determining a “rate of change of the residuals”, the fact that McBrien teaches the use of “horsepower” and includes graphs that show “slope” is clearly irrelevant. Specifically, the fact that FIG. 5 includes graphs that, as alleged by the Examiner, “therein show a slope, thus a rate of change” does not mean that McBrien actually teaches calculating such a “rate of change of sensor data residuals”. Instead, paragraph 0051 of McBrien makes clear that units 45a and 45b are performance maps developed by engine manufactures that are applied to conditioned values and multiplied. There is nothing in McBrien that even hints at units 45a and 45b being used to calculate any sort of “rate of change” of anything that could be considered a residual.

Third, with regard to cited paragraph 0057 of McBrien, this reference clearly describes that the “horsepower deviation ratios” are calculated through division of horsepower terms. When horsepower is divided by horsepower, the result is a unit-less ratio. A unit-less ratio does not express a rate of change, because it does not have the units of change. See the equation in paragraph 0057. Thus, McBrien cannot be said to teach the determination of a “rate of change of the residuals” in paragraph 0057.

Finally, if the Examiner is alleging that horsepower itself is a “rate of change” appellants again note that the claimed limitation is actually of a “rate of change of a residual”. As the Wikipedia reference (cited by the Examiner) states, the units of horsepower are “work over time”. “Work over time” cannot be said to be the “rate of change of sensor data residuals” because no “residual” was calculated in determining the horsepower before the “rate of change” was determined.

Appellants can thus find no teaching in McBrien of a sensor data processor that is configured to generate **residuals from sensor data** or the **rate of change of residuals from sensor data**.

Next, with regard to the fuzzy logic inference system and membership functions,

the Examiner again alleged that element 30 of McBrien constituted these elements. Specifically, the Examiner now alleges in response to Appellants previous arguments that the "boxes with mathematical symbols" (presumably elements 34 and 36) constitute the recited "membership functions". Appellants again disagree, and submit that element 30 of McBrien does not include any sort of fuzzy logic inference system as claimed. While FIG. 3 of McBrien does label element 30 using the phrase "fuzzy logic calculations", it is merely described as performing calculations relating to bypass, stopping or enabling the fault detection system. See FIG. 4 and paragraphs 0046-0048 of McBrien. For example, these sections describe how the element 30 determines if there are sufficient sensors available, and if not the fault detection logic is bypassed. Additionally, element 30 is described as determining the engine operating mode and likewise bypasses the fault detection logic if the engine is not in normal or combat roles. See paragraph 0047 of McBrien. Finally, appellants note that elements 34 and 36 are merely described as simple "summers". See paragraph 0046 of McBrien

In contrast, appellants' amended independent claims recite that the fuzzy logic inference system includes a plurality of membership functions and is configured to fuzzyify the augmented sensor data using plurality of membership functions. Specifically, independent claim 1 recites that the system fuzzifies the "residuals from the sensor data and the rate of change of the residuals using the plurality of membership functions". **Appellants can find no teaching of any membership functions or the use membership functions in a fuzzy logic system on residuals from sensor data, or on the rate of change of such residuals**.

As McBrien fails to teach either a sensor data processor or fuzzy logic inference system as claimed, appellants submit that independent claim 1 is patentably distinct over McBrien. Furthermore, as claims 5, 6, 7, 9, 10 and 11 depend from, and include all the limitations of independent claim 1, they are also submitted to be patentably distinct.

2. Claims 31, 33, 34, 36-38 are not unpatentable under 35 U.S.C. § 103 over McBrien in view of Martucci (U.S. Patent No. 6289274) and in further view of the Wikipedia document.

A. Rejections under 35 USC §103

Claims 31, 33, 34, 36-38 were rejected under 35 U.S.C. § 103 as allegedly being unpatentable over McBrien in view of Martucci (U.S. Patent No. 6289274) and in further view of the Wikipedia document. In making this rejection, the Examiner relied upon the same rational used for claims 1, 5-7, and 9-11, and further relied upon Martucci for teaching a memory coupled to the processor and storing programs.

B. Analysis

Appellants again disagree, and submit that amended independent claim 31 is patentably distinct over the cited references for similar reasons as was expressed with respect to claim 1. Specifically, the Martucci reference was simply cited as teaching a memory coupled to the processor and storing programs, and the reference thus does not overcome the deficiencies in McBrien noted above.

Specifically, appellants submit that that the McBrien reference fails to teach the recited sensor data processing program. Again, with regard to "generating residuals", appellants note the specification defines residuals as the difference between the sensor data and the expected values of the sensor data. See appellants' specification at page 5, lines 3-6. Appellants again submit that neither the cited "filtered" nor the cited "conditioned" sensor data meets the limitation of a generated "residual" from sensor data as the term is used in appellants' specification and claims.

With regard to determining a "rate of change of the residuals", Appellants again submit that the fact that McBrien teaches the use of "horsepower" and includes graphs that show "slope" is clearly irrelevant to the claimed limitation. Furthermore, the fact that FIG. 5 includes graphs that, as alleged by the Examiner, "therein show a slope, thus a rate of change" does not mean that McBrien actually teaches calculating such a rate of

change of any such residual. Again, appellants submit that it cannot be said that McBrien teaches the specific use of a "rate of change of a residual", when it only refers to the general term of "ratio". With regard to cited paragraph 0057 of McBrien, this reference clearly descries that the "horsepower deviation ratios" are calculated through division of horsepower terms. Appellants again submit that this does not disclose the recited determination of a rate of change, and that again, McBrien cannot be said to teach the determination of a "rate of change of the residuals".

Appellants can thus find no teaching in McBrien of any sensor data processing program configured to generate e **residuals from sensor data** or the **rate of change of residuals from sensor data**.

Next, with regard to the fuzzy logic inference program and membership functions, the Examiner again alleged that element 30 of McBrien constituted these elements. Appellants again disagree, and submit that element 30 of McBrien does not include any sort of fuzzy logic inference program as claimed. While FIG. 3 of McBrien does label element 30 using the phrase "fuzzy logic calculations", it is merely described as performing calculations relating to bypass, stopping or enabling the fault detection system. See FIG. 4 and paragraphs 0046-0048 of McBrien.

In contrast, appellants' amended independent claims recite that the fuzzy logic inference program includes a plurality of membership functions and is configured to **fuzzyify the augmented sensor data using plurality of membership functions**. Appellants can find no teaching of any membership functions or the use membership functions on residuals from sensor data, or on the rate of change of residuals.

Thus independent claim 31, like independent claim 1, is submitted to be patentably distinct over the cited references. Furthermore, as claims 33, 34 and 36-38 depend from, and include all the limitations of claim 31, they are also submitted to be patentably distinct.

3. Claims 39-45 are not unpatentable under 35 U.S.C. § 103 over McBrien in view of Brown et al (U.S. Patent No.5377112).

A. Rejections under 35 USC §103

Claims 39-45 were rejected under 35 U.S.C. § 103 as allegedly being unpatentable over McBrien in view of Brown et al (U.S. Patent No.5377112). With regard to McBrien, this rejection is based on most of the same rational as that given with respect to claim 1. With regard to Brown, the Examiner relies on Brown to teach sensor data that includes exhaust gas temperature data, engine speed data, and fuel flow data, and the generating of residuals of these data types.

B. Analysis

Appellants again disagree, and submit that independent claim 39 is patentably distinct over the cited references for similar reasons as was expressed with respect to claims 1 and 31.

Again, with regard to the sensor data processor, the Examiner alleged that elements 14 and 16 of McBrien constitute the recited sensor data processor, stating that these elements are configured to receive sensor data, generate residuals and determine a rate of change of the residuals.

Appellants submit that this is a misreading of the McBrien reference, and that the McBrien reference fails to teach the recited sensor data processor.

Again, with regard to the sensor data processor being configured to "generate residuals", appellants note the specification defines residuals as the difference between the sensor data and the expected values of the sensor data. Furthermore, independent claim 39 recites specific types of data from which the residuals are calculated. Specifically, claim 39 recites the calculation of residuals from exhaust gas temperature data, engine speed data, and fuel flow.

Furthermore, the claim specifically recites the technique used to calculate such residuals. Specifically, the claim recites that the sensor data processor is configured to "generate exhaust gas temperature residuals by comparing the exhaust gas temperature data to expected values of exhaust gas temperature", "generate engine speed residuals by comparing the engine speed data to expected values of engine speed", and "generate fuel flow residuals by comparing the fuel flow data to expected values of fuel flow". Nothing in the cited portion of McBrien is seen as teaching these specific determinations.

Next, with regard to determining a "rate of change of the residuals", the Examiner cited paragraphs 0050 and 0051 of McBrien as teaching these features, and specifically recited "filtered or conditioned data" that is described in McBrien. Again, appellants disagree, and submit that "filtered" or "conditioned" data cannot meet this limitation. Again, there is nothing in the cited portion of McBrien that is seen as meeting the limitation of the various residuals defined in the claim itself, or of a rate of change of the residuals recited in the claim itself.

Next, with regard to the fuzzy logic inference system and membership functions, the Examiner again alleged that element 30 of McBrien constituted these elements. Appellants again disagree, and submit that element 30 of McBrien does not include any sort of fuzzy logic inference system as claimed. While FIG. 3 of McBrien does label element 30 using the phrase "fuzzy logic calculations", it is merely described as performing calculations relating to bypass, stopping or enabling the fault detection system.

In contrast, appellants' amended independent claims recite that the fuzzy logic inference system includes a plurality of membership functions and is configured to fuzzyify the augmented sensor data using plurality of membership functions.

Furthermore, applicants submit that McBrien further fails to teach the specific limitations of claim 39. For example, McBrien does not teach a fuzzy logic system that is

"configured to fuzzify the exhaust gas temperature residuals, the engine speed residuals, the fuel flow residuals, the rate of change of the exhaust gas temperature residuals, the rate of change of the engine speed residuals, and the rate of change of the fuel flow residuals **using the plurality of membership functions**" (emphasis added). Again, applicants note that the Examiner apparently cites summers as being membership functions, but did not cite any particular portion of McBrien as teaching the use of membership functions with regard to the specific residual types and residual rate of changes.

Next, with regard to Brown, the Examiner relies on Brown to teach sensor data that includes exhaust gas temperature data, engine speed data, and fuel flow data, and the generating of residuals of these data types. Appellants submit that this is also incorrect for several reasons. First, the Examiner seems to rely on the implied teaching of "comparing and taking difference" as teaching the specific calculation of residuals from specific types of data. Again, appellants submit that this is clearly incorrect, as none of the cited portions in Brown discuss the comparison of the specific data types to any such expected values, or the determination of the rate of change of such residuals. Thus, while Brown does discuss the use of exhaust gas temperature and other types of data, it does not teach the specific determinations of residuals to these types of data or the calculation of rates of changes of residuals of these types of data.

As McBrien fails to teach a sensor data processor or fuzzy logic inference system as claimed, and as Brown fails to teach any generation of residuals of the recited data types, or rates of change of such residuals, applicants submit that independent claim 39 is patentably distinct over McBrien and Brown. Furthermore, as claims 40-45 depend from, and include all the limitations of independent claim 39, they are also submitted to be patentably distinct.

Furthermore, with regard to claims 40 and 41, no part of either reference is seen as teaching low membership functions, high membership functions, medium membership

functions, or any membership functions that comprise a first sigmoid function, a trapezoid function, or a second trapezoid function. Again, the only elements cited as membership functions appear to be summers.

Finally regard to claim 43, no part of either reference is seen as teaching the calculation of a centroid under the aggregated output function.

4. Conclusion

In view of the foregoing, Appellants submit that the rejection of Claims 1, 5-7, 9-11, 31, 33-35 and 37-45 is improper and should not be sustained. Therefore, a reversal of the rejections in the Office Action dated May 12, 2009, is respectfully requested.

Respectfully submitted,
INGRASSIA FISHER & LORENZ, P.C.

Dated: October 13, 2009

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VIII. CLAIMS APPENDIX

Claims on Appeal

1. A fault detection system for detecting faults in a turbine engine, the fault detection system comprising:

   a sensor data processor, the sensor data processor configured to receive sensor data from the turbine engine and generate residuals from the sensor data and determine a rate of change of the residuals, the residuals from the sensor data and the rate of change of the residuals providing an augmented data set; and

   a fuzzy logic inference system, the fuzzy logic inference system configured to receive the augmented data set, and wherein the fuzzy logic inference system includes a plurality of membership functions and wherein each of the plurality of membership functions is associated with at least one data type in the residuals from the sensor data and the rate of change of the residuals, and wherein the fuzzy logic system is configured to fuzzify the residuals from the sensor data and the rate of change of the residuals using the plurality of membership functions and analyze the residuals from the sensor data and the rate of change of the residuals to determine a likelihood that a fault has occurred in the turbine engine.

2. (withdrawn).

3. (cancelled).

4. (cancelled)

5. The system of claim 1 wherein the sensor data processor is further configured to compute a margin for the sensor data.

6. The system of claim 1 wherein the sensor data comprises engine speed data, fuel flow data and exhaust gas temperature data.

7. The system of claim 1 wherein the sensor data processor is configured to receive exhaust gas temperature data and wherein the sensor data processor is further configured to determine exhaust gas temperature margin data corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.

8. (cancelled)

9. The system of claim 1 wherein the fuzzy logic inference system includes a plurality of rules, and wherein the fuzzy logic system is configured to evaluate the fuzzified residuals from the sensor data and the rate of change of the residuals according to the plurality of rules.

10. The system of claim 9 wherein the fuzzy logic inference system is further configured to aggregate outputs of the plurality of rules and defuzzify the aggregated output for input into a diagnostic system.

11. The system of claim 10 wherein the sensor data comprises exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor is configured to generate residuals from the exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor is configured to determine a rate of change of the residuals from the exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor is configured to determine a margin for the exhaust gas temperature data corresponding to a difference between the exhaust gas temperature data and a maximum safe exhaust gas temperature for the turbine engine.

12. (cancelled)

13. (cancelled)

14. (cancelled) .

15. (cancelled)

16. (cancelled)

17. (cancelled)

18. (cancelled).

19. (cancelled).

20. (cancelled)

21. (withdrawn)

22. (cancelled)

23. (cancelled)

24. (cancelled)

25. (withdrawn)

26. (withdrawn)

27. (cancelled)

28. (withdrawn)

29. (withdrawn)

30. (withdrawn).

31. An apparatus comprising:

a) a processor;

b) a memory coupled to the processor;

c) a fault detection program residing in memory and being executed by the processor, the fault detection program including:

i) a sensor data processing program, the sensor data processing program configured to receive sensor data from a turbine engine and generate residuals from the sensor data and determine a rate of change of the residuals, the residuals from the sensor data and the rate of change of the residuals providing an augmented data set; and

ii) a fuzzy logic inference program, the fuzzy logic inference program configured to receive the augmented data set, and wherein the fuzzy logic inference program includes a plurality of membership functions and wherein each of the plurality of membership functions is associated with at least one data type in the residuals from the sensor data and the rate of change of the residuals, and wherein the fuzzy logic program is configured to fuzzify the residuals from the sensor data and the rate of change of the residuals using the plurality of membership functions and analyze the residuals from the sensor data and the rate of change of the residuals to determine a likelihood that a fault has occurred.

32. (cancelled)

33. The apparatus of claim 31 wherein the sensor data comprises engine speed data, fuel flow data and exhaust gas temperature data.

34. The apparatus of claim 31 wherein the sensor data processing program is configured to receive exhaust gas temperature data and wherein the sensor data processor is further configured to determine exhaust gas temperature margin data corresponding to a difference between the exhaust gas temperature data and a selected maximum safe exhaust gas temperature for the turbine engine.

35. (cancelled)

36. The apparatus of claim 31 wherein the fuzzy logic inference program includes a plurality of rules, and wherein the fuzzy logic system is configured to evaluate the fuzzified residuals from the sensor data and the rate of change of the residuals according to the plurality of rules.

37. The apparatus of claim 36 wherein the fuzzy logic inference program is further configured to aggregate outputs of the plurality of rules and defuzzify the aggregated output for input into a diagnostic system.

38. The apparatus of claim 31 wherein the sensor data comprises exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processing program is configured to generate residuals from the exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processing program is configured to determine a rate of change of the residuals from the exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processing program is configured to determine a margin for the exhaust gas temperature data corresponding to a difference between the exhaust gas temperature data and a maximum safe exhaust gas temperature for the turbine engine.

39. A fault detection system for detecting faults in a turbine engine, the fault detection system comprising:

a sensor data processor, the sensor data processor configured to:

receive sensor data from the turbine engine, the sensor data including exhaust gas temperature data, engine speed data, and fuel flow data;

generate exhaust gas temperature residuals by comparing the exhaust gas temperature data to expected values of exhaust gas temperature;

generate engine speed residuals by comparing the engine speed data to expected values of engine speed;

generate fuel flow residuals by comparing the fuel flow data to expected values of fuel flow;

determine a rate of change of the exhaust gas temperature residuals;

determine a rate of change of the engine speed residuals;

determine a rate of change of the fuel flow residuals; and

a fuzzy logic inference system, the fuzzy logic inference system configured to receive the exhaust gas temperature residuals, the engine speed residuals, the fuel flow residuals, the rate of change of the exhaust gas temperature residuals, the rate of change of the engine speed residuals, and the rate of change of the fuel flow residuals, and wherein the fuzzy logic inference system includes a plurality of membership functions, and wherein the fuzzy logic system is configured to fuzzify the exhaust gas temperature residuals, the engine speed residuals, the fuel flow residuals, the rate of change of the exhaust gas temperature residuals, the rate of change of the engine speed residuals, and the rate of change of the fuel flow residuals using the plurality of membership functions to determine a likelihood that a fault has occurred in the turbine engine.

40. The system of claim 39 wherein the plurality of membership functions include a low membership function, a medium membership function, and a high membership function.

41. The system of claim 40 wherein the low membership function comprises a first sigmoid function, and wherein the medium membership function comprises a trapezoid function, and wherein the high membership function comprises a second sigmoid function.

42. The system of claim 40 wherein the fuzzy logic inference system is configured to fuzzify the exhaust gas temperature residuals, the engine speed residuals, the fuel flow residuals, the rate of change of the exhaust gas temperature residuals, the rate of change of the engine speed residuals, and the rate of change of the fuel flow residuals using the plurality of membership functions by generating an aggregated output function from the plurality of membership functions.

43. The system of claim 42 wherein the fuzzy logic inference system is configured to determine a likelihood that a fault has occurred in the turbine engine by determining a centroid of area under the aggregated output function.

44. The system of claim 43 wherein the fault comprises a high pressure spool fault.

45. The system of claim 39 wherein the sensor data processor is configured to determine the rate of change of the exhaust gas temperature residuals using a linear fit of the exhaust gas temperature residuals, and wherein the sensor data processor is configured to determine the rate of change of the engine speed residuals using a linear fit of the engine speed residuals, and wherein the sensor data processor is configured to determine the rate of change of the fuel flow residuals using a linear fit of the fuel flow residuals.

IX. EVIDENCE APPENDIX

No evidence pursuant to 37 C.F.R. §§ 1.130, 1.131, or 1.132 has been entered by the Examiner or relied upon by Appellant in the instant appeal beyond that which is already contained in the as-filed application, as is delineated in the Arguments section of this Brief.

X. RELATED PROCEEDINGS APPENDIX

As there are no related appeals and interferences, there are also no decisions rendered by a court or the Board of Patent Appeals and Interferences that are related to the instant appeal.